COCHISE CONSERVATION AND RECHARGE NETWORK (CCRN)

Ephemeral Streamflow, Groundwater, and Palominas Facility Monitoring

Presentation to Upper San Pedro Partnership (USPP)
Technical Committee
June 19, 2019

CCRN MONITORING

Acknowledgements

Thank you Upper San Pedro Partnership for having us here today!

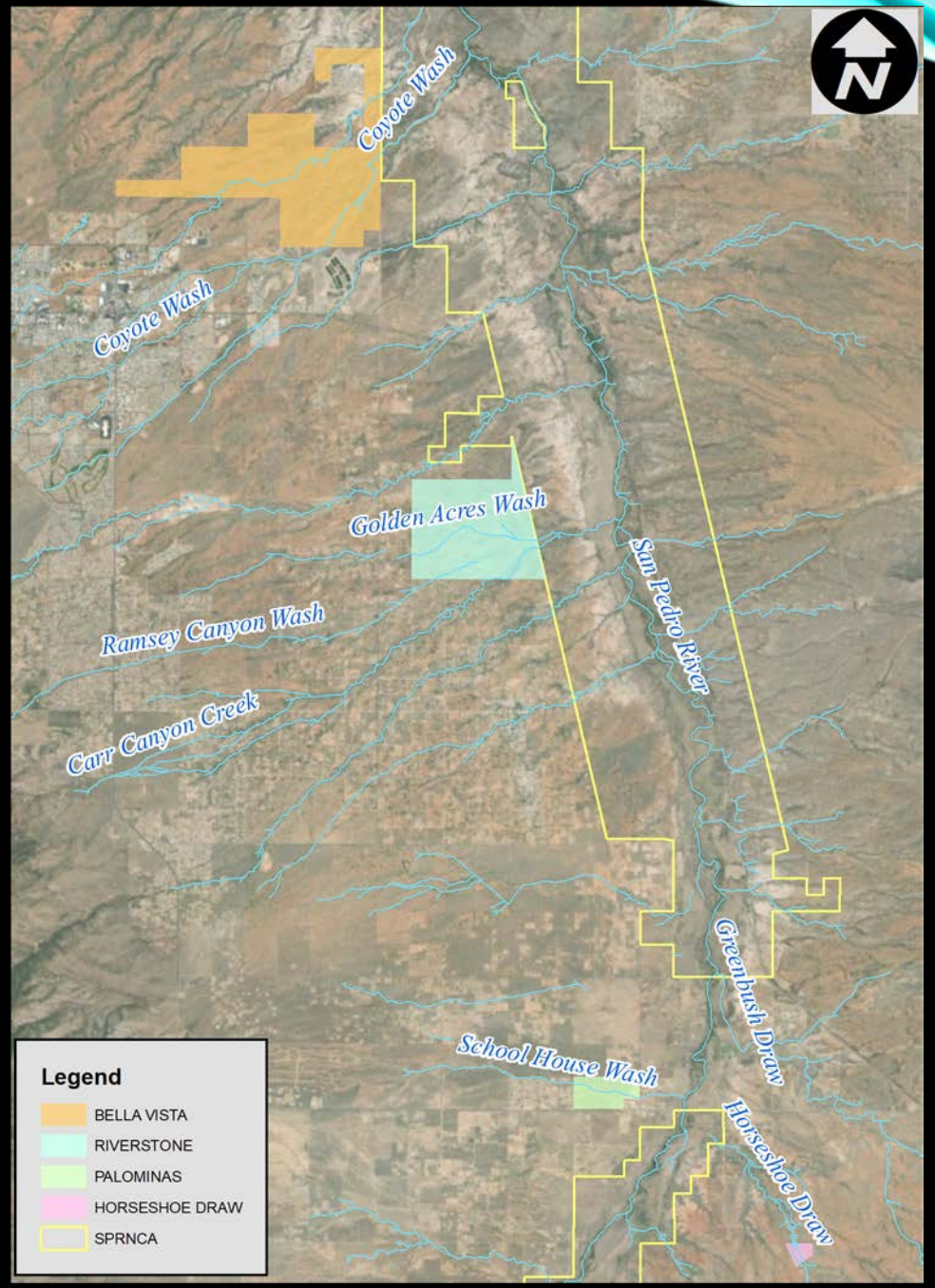
CCRN MONITORING

Purpose and Objectives

The purpose of the Cochise Conservation and Recharge Network (CCRN) is to implement a **regional network of water-management projects** that meet the long-term needs of the Upper San Pedro River in the Sierra Vista subwatershed. The objectives of the CCRN hydrologic monitoring program are to **quantify and continuously improve the design and effectiveness of CCRN aquifer recharge projects, and to aid in addressing legal and regulatory compliance**.

CCRN MONITORING

- Bella Vista
  - **Coyote Wash**
- Riverstone
  - **Golden Acres Wash**
  - **Ramsey Canyon Wash**
  - **Carr Canyon Creek**
- Palominas
  - **Facility, School House Wash and upstream tributaries**
- Horseshoe Draw
  - **Horseshoe Draw and Facility**



CCRN MONITORING

Reasons for Monitoring ("Why")

1. Document and track groundwater elevations, trends, gradients, etc. for either baseline conditions (pre-project) or observed effects (post-project)
2. Measure precipitation at various locations throughout contributing watersheds
3. Estimate natural surface water runoff flow rates and annual delivery volumes for baseline conditions
4. Estimate project facility inflow and outflow rates and annual volumes
5. Estimate aquifer recharge volumes resulting from constructed facilities, and compare pilot project recharge enhancement features

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PRESSURE TRANSDUCERS

- Installed in vented steel pipe housing
- Measure weight of water above sensor, derive depth
- Deployed at various locations throughout monitored watersheds
- Co-located (generally) with barometric pressure PT to compensate for atmospheric pressure

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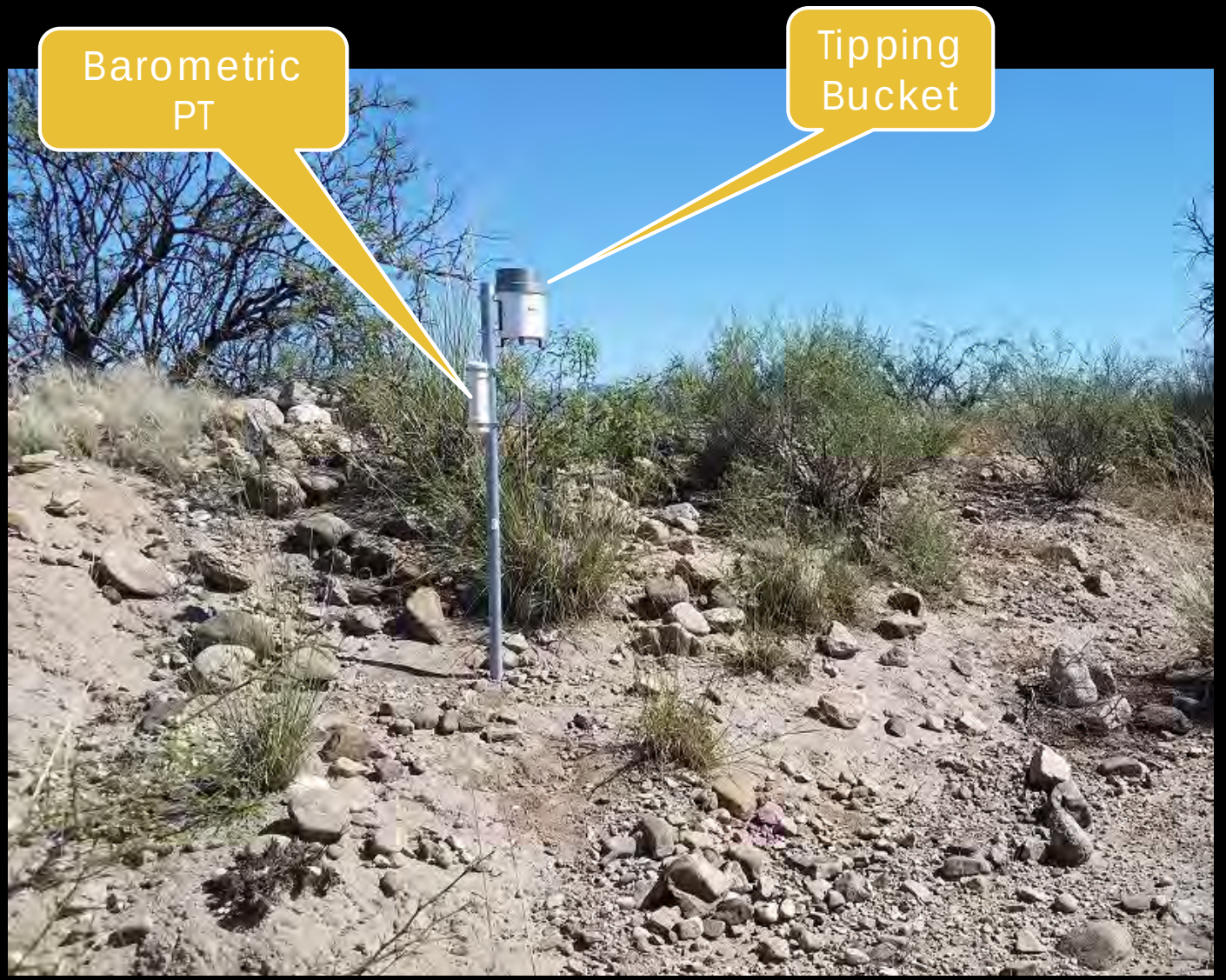
PRECIPITATION GAUGE

- Tipping Bucket Precipitation Gauge
- Internal Datalogger
- (Optional: Barometric PT)

Precip. data recorded on 15-minute intervals

Barometric Pressure data recorded to adjust nearby surface water PT measurements



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CONTINUOUS SLOPE-AREA METHOD

- Pressure Transducers (4 min.) on channel cross sections

PT data are analyzed using program called Slope-Area Method Discharge Calculator (SAMDC)

Output from program provides complete-event hydrograph, including runoff volumes, peak Q, duration

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UPLAND BASIN

- 1 Pressure Transducer in Stock Ponds

Using topography data provided by the County, a regression equation relating Area (A) and Depth (d) was developed

PT data is analyzed by integrating areas from depth data up to end of rising limb, to estimate and sum incremental volumes

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CULVERT CROSSING

- 1 Pressure Transducer at Culvert Inlet

HY-8 rating of culvert to develop regression equation of discharge given flow depth

Volumes estimated by integrating hydrograph

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ROAD CROSSING

- 1 Pressure Transducers at a dip section (at-grade crossing)

Weir rating of dip geometry to develop regression equation of discharge given flow depth

Volumes estimated by integrating hydrograph

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HEC-RAS STATION

- 2 Pressure Transducers on 3 channel cross sections (downstream used for setting boundary condition)

HEC-RAS rating of cross sections to develop regression equation of discharge given flow depth

Volumes estimated by integrating hydrographs at each sensor

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SURFACE WATER IMAGERY

- Staff Gauge
- Remote Camera, Internal Image Storage

Images are collected every 15 minutes and reviewed to estimate maximum depths, durations of flows.

Beneficial for verifying PT data, and for observing flow characteristics.

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INSTRUMENTED BOREHOLES

- Level 1: Soil Moisture Sensors and Datalogger
- Level 2: Soil Moisture Sensor, Advanced Tensiometer and Datalogger

Level 1 Measure and record soil volumetric water content and temperature

Level 2 also measure soil moisture soil water potential

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STILLING WELLS

- 1 Pressure Transducer in PVC housing

Deployed on Palominas facility at locations to measure depth of flow or ponding

Analysis methods vary depending on the installation

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<u>GROUNDWATER MONITORING WELL</u>

- 1 PT lowered into well casing tethered to a cable
- (Optional) measured manually

Measure depth of groundwater above PT, over time

Based on ground elevation measurements or estimates, groundwater elevations are determined

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CROSS SECTION SURVEYS

- Real Time Kinetic (RTK) satellite positioning survey of channel cross sections
- Based on local benchmarks (relative)
- Repeat annual surveys to monitor channel change

Date	Site	Station	Maintenance Conducted
9/12/2017	Bella Vista	Rain Gauge	Battery shorted out, no data, lid knocked off. Replaced Rain Gauge
		CY2-A	Was knocked over and buried, re-installed
		CY2-B	Was knocked over and buried, re-installed
11/8/2017		CY1-B	Replaced PT
		CY1-C	Replaced PT
5/16/2018		Coyote Wash SWI	Installed new SWI station adjacent to CY2-B
9/10/2018		Gravel Pit Well	Replaced PT, was beginning to fail
		CY1-A	Located buried PT with metal detector, re-installed
1/30/2019		CY1-A	Replaced PT, erratic baseline
9/11/2017	Horseshoe Draw	HD1-B	Installed new PT and PT housing
9/4/2018		HD1-C	Replaced PT
9/12/2017	Palominas	RG3 (Indigo Sky)	Cleared plugged inlet
2/9/2018		East Well	Replaced PT
5/16/2018		KR-C2	Relocated stilling well to base of culvert
10/25/2018		RG2 (King's Ranch)	Stabilized base of rain gauge post with cement
10/30/2018		MV1-A	Replaced PT
1/16/2019		RG2 (King's Ranch)	Replaced rain gauge
1/30/2019		Baro PT (in West Well)	Replaced failed Barometric PT
7/26/2017	Riverstone	CC1-A	Replaced PT
11/8/2017		CC1-A'	Replaced PT
2/9/2018		SW1 (GA-1)	Replaced failed PT
5/16/2018		CC1-C	Replaced PT
		SW3 (RC-2)	Replaced PT at drop structure
		Carr Canyon SWI	Installed new SWI station adjacent to CC1-B
8/3/2018		CC1-A'	PT knocked over, re-installed
		Carr Canyon SWI	Camera found with BB hole through lens
9/4/2018		Carr Canyon SWI	Replaced Camera due to BB damage
		Drop Structure SWI	Replaced Camera
9/10/2018		East Well	Installed new LevelTroll 400
10/26/2018		Carr Canyon SWI	SD card stolen, replaced
1/30/2019		CC1-B	Replaced failed PT

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MAINTENANCE

- Scheduled quarterly routine maintenance is an integral part of the program
- Concurrent with data download visits
- Verify presence and function of sensors
- Clear accumulated debris and sediment (housings tend to accumulate sand)

RESULTS

Prior monitoring period: calendar years 2017 & 2018

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RESULTS: BELLA VISTA

Precipitation Summary

Year	Precipitation Depth (in.)	Classification (below <10.3 in. average 19.1 in.<above) NCDC 2012, 2015
2017	8.4	Dry
2018	14.8	Average

CCRN MONITORING

RESULTS: BELLA VISTA

Runoff Summary, Coyote Wash

Year	Station*	Peak Stage (ft.)	Estimated Total Runoff (Ac. Ft.)
2017	CY2	0.5	6.2
	CY1	0.6	2.7
2018	CY2	0.9	25.5
	CY1	1.6	70.8

* Station CY2 is UPSTREAM of Station CY1

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RESULTS: BELLA VISTA

Surface Water Imagery

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RESULTS: BELLA VISTA

Groundwater

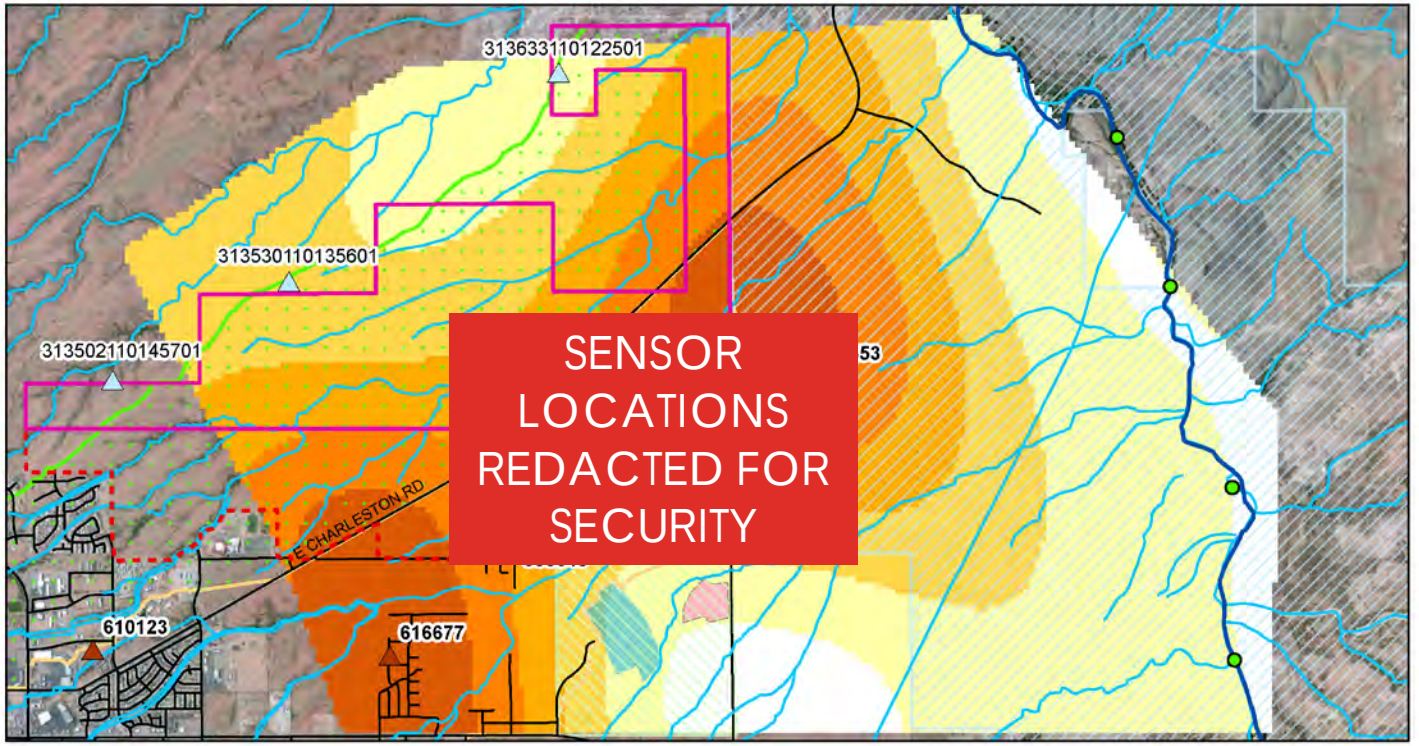

Figure 12. Estimated change in groundwater elevation at Bella Vista from November 2016 to November 2018.

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GSA GeoSystems Analysis, Inc. Innovative Solutions

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RESULTS: RIVERSTONE

Precipitation Summary

Year	Precipitation Depth (in.)	Classification below <10.3 in. average 19.1 in.<above (NCDC 2012, 2015)
2017	8.6	Dry
2018	12.3	Average

CCRN MONITORING

RESULTS: RIVERSTONE

Runoff Summary, Carr, Ramsey Canyon, Golden Acres Wash

Year	Station*	Peak Stage (ft.)	Estimated Total Runoff (Ac. Ft.)
2017	CC1	0.7	1.9
	SW-1	0.0	0.0
	SW-2	1.6	1.3
	SW-3	0.0	0.0
2018	CC1	0.8	31.9
	SW-1	1.3	1.1
	SW-2	1.3	3.5
	SW-3	0.0	0.0

*Station SW-2 is UPSTREAM of Station SW-3, which is UPSTREAM of Station CC1

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RESULTS: RIVERSTONE

Surface Water Imagery

Note:
Vandalism and theft caused the loss of SWI data from CC1

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RESULTS: RIVERSTONE

Groundwater

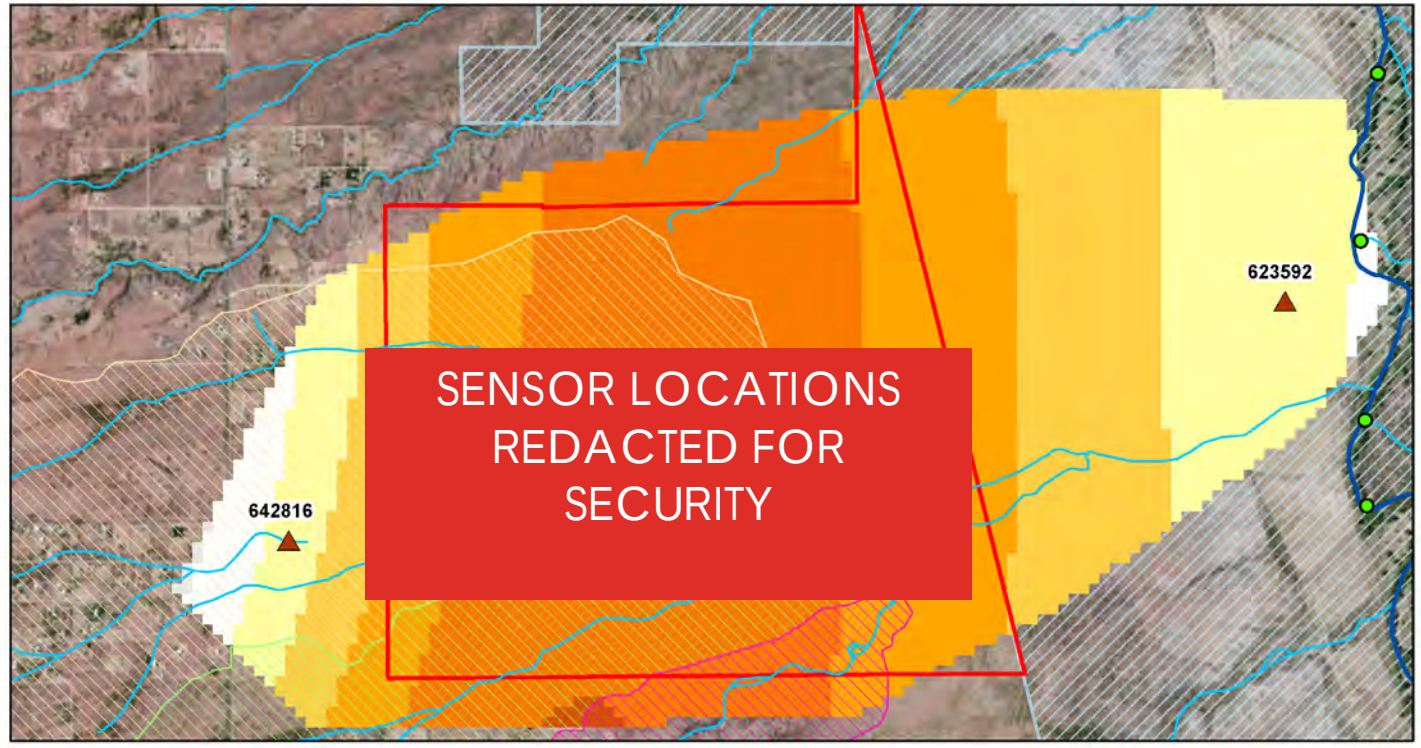

Figure 14. Estimated change in groundwater elevation at Riverstone from November 2016 to November 2018

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RESULTS: PALOMINAS

Precipitation Summary

Year	Precipitation Depth (in.)	Classification below <10.3 in. average 19.1 in.<above (NCDC 2012, 2015)
2017	10.5	Average
2018	19.3	Wet

Precipitation depth reported is average of 3 gauges

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RESULTS: PALOMINAS

Runoff Summary, Schoolhouse Wash

Year	Station*	Peak Stage (ft.)	Estimated Total Runoff (Ac. Ft.)
2017	KR-C1	0.5	3.4
	KR-C2	0.0	0.1
	KR-RC2	0.7	36.3
	MV-1	1.3	4.4
2018	KR-C1	0.8	1.6
	KR-C2	0.5	6.0
	KR-RC2	0.6	13.3
	MV-1	0.6	3.3

*Stations are listed UPSTREAM to DOWNSTREAM

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RESULTS: PALOMINAS

Surface Water Imagery

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RESULTS: PALOMINAS

Aquifer Recharge, Facility, Entire Period of Record

Summary of Annual Precipitation and Estimated Recharge Volumes

Year	Precipitation (in.) [Classification]	Estimated Annual Recharge Volume (AF)
July 2014-June 2015	24.1 [Wet]	35.8
July 2015-June 2016	18.7 [Average]	15.3
July 2016-June 2017	14.8 [Average]	11.1
2017	10.0 [Dry]	9.7
2018	19.3 [Wet]	10.2

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RESULTS: PALOMINAS

Groundwater

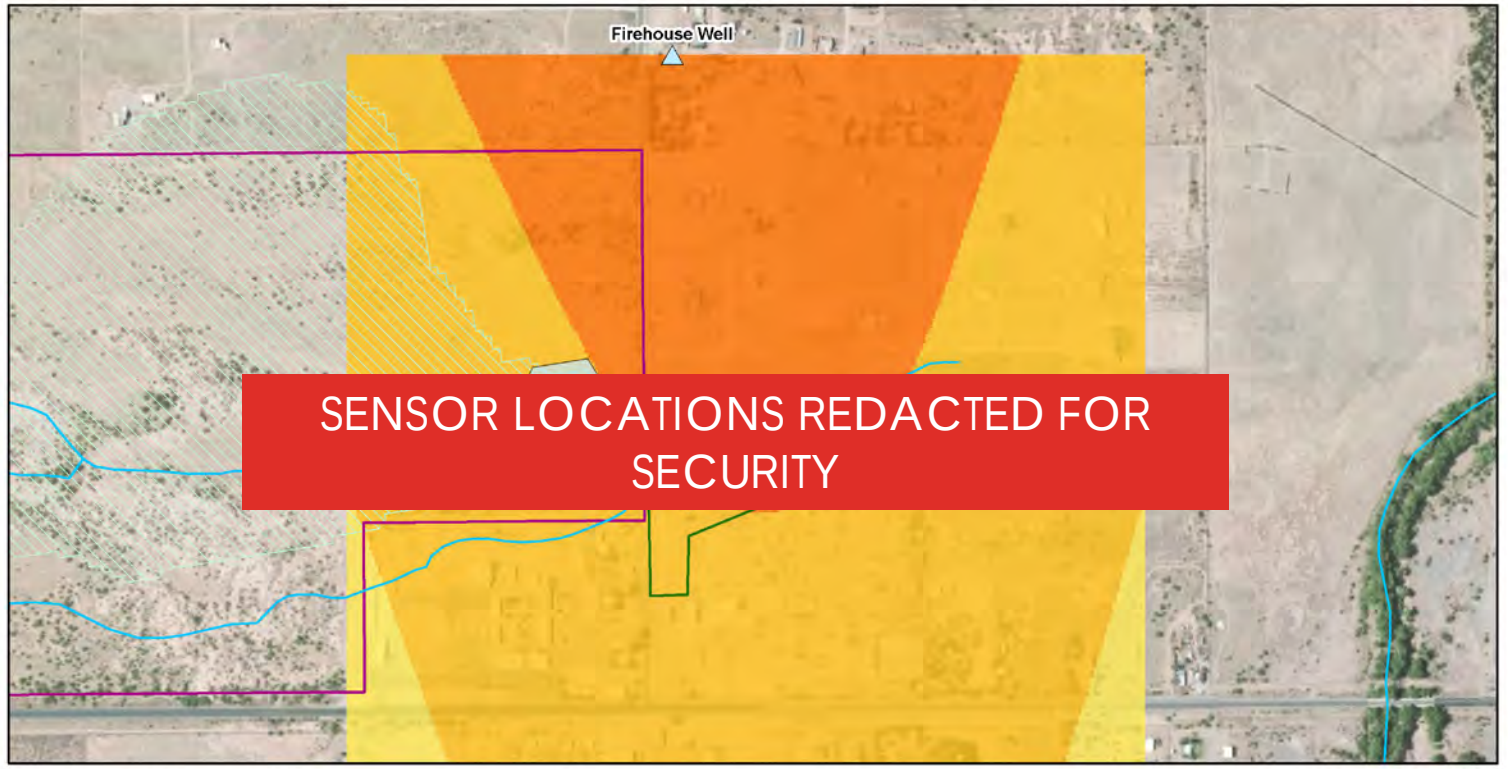

Figure 16. Estimated change in groundwater elevation at Palominas, June/July 2014 to July 2018

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RESULTS: HORSESHOE DRAW

Precipitation Summary

Year	Precipitation Depth (in.)	Classification below <10.3 in. average 19.1 in.<above (NCDC 2012, 2015)
2017	6.2	Dry
2018	15.1	Average

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RESULTS: HORSESHOE DRAW

Runoff Summary, Horseshoe Draw

Year	Station*	Peak Stage (ft.)	Estimated Total Runoff (Ac. Ft.)
2017	HD-1	1.0	106.0
2018	HD-1	1.0	80.9

Note: Facility monitoring equipment was installed in late 2018; no events were detected during the monitoring period

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CONCLUSIONS

1. We are testing and refining different types of sensor/station configurations and data analysis methods to detect and measure surface flows and groundwater conditions.
2. Periodic maintenance is required at all stations to counter equipment failure, damage and theft/vandalism.
3. Low amounts/intensities of rainfall yield low amounts of runoff. To speculate, continued low rainfall periods may cause very low antecedent moisture conditions and compound the low runoff response.
4. Many precipitation events produce little or no runoff detected at our stations.
5. Given the spatial and temporal distribution of precipitation events, some ephemeral streams my be considered influent (water losing).

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CONCLUSIONS (CONT.)

6. Groundwater levels generally declined over the monitoring period.
7. Palominas recharge facility showed an increase (mound) in groundwater elevations following Hurricane Odile (Sept. 2014) at monitoring wells near the facility, but followed regional declines thereafter.
8. Additional continued monitoring is recommended to provide a record from which hydrologic modeling methods can be refined.

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SUMMARY*

CCRN Hydrologic Monitoring and Modeling:

- Precipitation and surface water flow monitoring from 2014-2018 demonstrates variability in space and time of storms and corresponding runoff events across the Sierra Vista Subwatershed (different watercourses and project locations).
- Acknowledges that annual monitoring may estimate less runoff than models predict, however, the historical period of record data shows high flows have been observed at other locations in the Subwatershed.
- Observations suggest the need to build stormwater projects to take advantage of available water in the best predicted locations and downstream of the greatest magnitudes of runoff.

*Summary of topics discussed during and following the presentation

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SUMMARY (CONT.)*

CCRN Design Philosophy and Approach:

- Uses the best available and economical methods to gather data and develop predictive surface water models.
- Includes reviews by the USPP Technical Committee.
- Acknowledges that stormwater recharge facilities will remain dependent upon precipitation rates which vary year to year, however, anticipates that recharge project benefits will be relevant over the long-term, regardless of annual local precipitation variability.

*Summary of topics discussed during and following the presentation